§30. Confinements of Energetic Particles in Quasi-axisymmetric Configurations

S. Murakami, N. Nakajima, M. Okamoto

Confinement of energetic particle is an important issue for fusion reactor. In quasi-axisymmetric (QA) configurations the toroidal angular momentum is approximately conserved in the Boozer coordinates and particle confinement would be improved considerably without assuming strong radial electric field[1]. However, in actual QA devices, the existence of small non-axisymmetric components is inevitable and the amplitude of these components are relatively large compared with that of tokamaks, where the ripple enhanced losses of energetic particles are one of the important problems. Therefore, in QA devices, the non-axisymmetric components of magnetic filed would also enhance similar ripple loss of energetic particles.

In this paper we study the effect of non-axisymmetric magnetic field components on energetic particle confinements in QA configurations by means of orbit following Monte Carlo simulations. We consider a typical QA configuration[2] (the major radius R_0=2.0m, the minor radius a=0.46m, and the magnetic field strength B_0=2T). Figure 1 shows the amplitude of non-axisymmetric components by plotting $\delta(r,\theta)$,

$$\delta(r,\theta) = [B_{max}(r,\theta)-B_{min}(r,\theta)]/[B_{max}(r,\theta)+B_{min}(r,\theta)]$$

on the (r,θ) plane. The amplitude of δ is small near the center region and increases at the plasma edge. The amplitude of δ at the plasma edge reaches more than 3% in this configuration.

We follow the collisionless orbit of energetic particle changing the particle energy and configurations. The drift motion are solved in the Boozer coordinates based on the obtained MHD equilibrium. Initially we set the energetic particles on the flux surface $r/a=1/4$ and the particles are randomly distributed in the poloidal and toroidal directions.

The confinement of energetic particles are investigated by evaluating the loss rate of energetic particles. Figure 2 shows the loss rate of energetic particles with the energies E_0=20keV, 40keV, 60keV and 80keV. The large direct orbit loss (loss in very short time scale <0.1ms) can be seen in the case of E_0=80keV because of large banana width. It is also found that the loss rates increase in time and that almost trapped particles (about 12% of total particle number) are lost after few 10ms except the 10keV case. The test particle orbits show that the large change of the position of banana orbit due to the banana-drift diffusion. Therefore it is concluded the large loss of energetic particles would be observed due to the banana-drift diffusion.

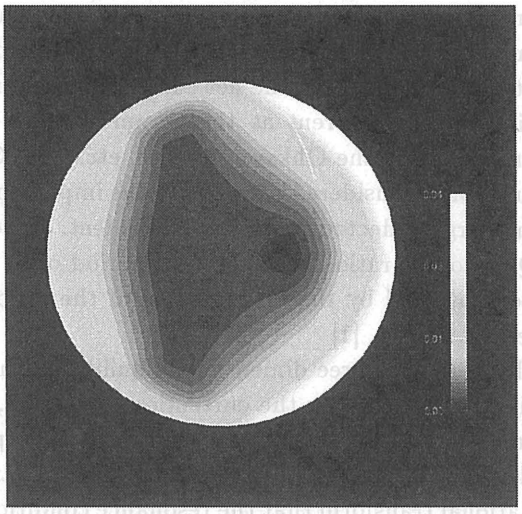

Fig. 1 Amplitudes of non-axisymmetric components in QA configurations.

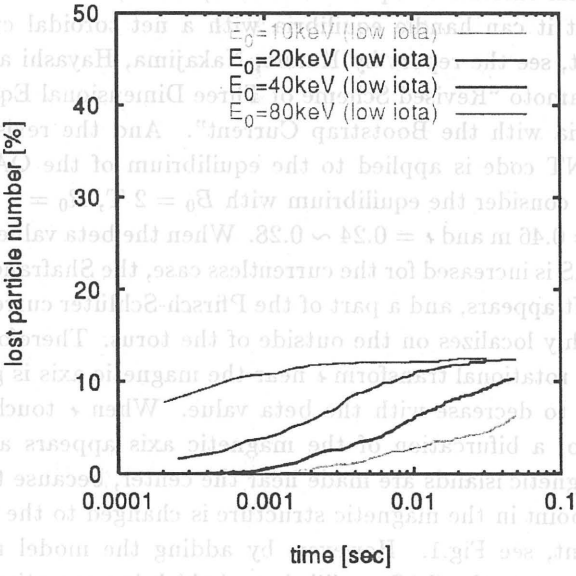

Fig. 2 Loss rate of energetic particles in Quasi-axisymmetric configurations.

REFERENCES

[1] J. Nührenberg in Theory of Fusion Plasmas (Proc. Workshop Varenna, 1994) Editrice Compositori, Bologna (1994) 3.

[2] S. Okamura et al., in Proc. Joint Conf. 11th Int. Stellarator Conf. and 8th Int. Toki Conf., (1998) NR-5.